Space Communications Technology Link

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Changing the way NASA and the Nation Communicate through Space

Enhancing Space-Based Networking with Standard Internet Protocols

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The Internet Engineering Task Force's (IETF) TCP Over Satellite working group has recently made a number of recommendations for using standard Internet protocols over space channels [AGS99]. Utilizing these enhancements will allow NASA to use inexpensive off-the-shelf protocols in near Earth scientific missions.

The IETF recommended several mechanisms for efficient operation of the Transmission Control Protocol (TCP) over satellite-based channels. The first mechanism is Forward-Error Correction (FEC). While TCP is a reliable protocol, meaning that lost or corrupted data is retransmitted when detected, unnecessary packet drops can hurt performance. TCP contains a set of congestion control algorithms which are used to enable many traffic flows to share the same network channel. When TCP notices that a network path is congested, it reduces the rate at which it transmits packets.

Currently, congestion is detected via packet drops (TCP assumes that a dropped packet indicates that a queue in the network path has overflowed). Therefore, if a packet is dropped due to corruption, TCP will react as if

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Global Navigation Satellite System (GNSS) – What Is It?

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In the Space Communications Technology Link Issue Volume 2, No. 1 dated April 1999, the article titled “Global Positioning System (GPS)—Protection of Radio Spectrum Supporting the Global Navigation Satellite System (GNSS)” was discussed including the factors effecting the good health and continued reliability of the GPS System.

WHAT IS SATELLITE NAVIGATION?

Satellite Navigation is based on a global network of satellites that transmit radio signals from approximately eleven thousand miles in high earth orbit. Users of Satellite Navigation are most familiar with the Global Positioning System (GPS) constellation of twenty-four satellites (currently there are 27 GPS satellites in orbit). The United States, which developed and operates GPS; and Russia, which developed a similar system known as GLONASS, have offered the international community the free use of their respective systems. The International Civil Aviation Organization and the International Maritime Organization have accepted GPS and GLONASS as the core of an international civil capability in Satellite Navigation known as the Global Navigation

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On our Cover

(Space-Based Networking continued.)

congestion occurred and reduce its sending rate because TCP cannot differentiate between congestion and corruption. This reduction in sending rate hurts performance. Until an algorithm for differentiating between congestion and corruption based losses is developed and widely tested, the IETF recommends links be made as "clean" as possible.

The second suggestion is use of the IETF's Path MTU Discovery mechanism [MD90] to determine the largest possible packet size supported by the intervening network path. Using larger packets reduces the bandwidth used by TCP/IP headers because the same amount of data can be transferred with less packets (and therefore less headers).

The next suggestion is use of standard TCP congestion control algorithms [Ste97,APS99]. Without these algorithms there is a real chance that a network can suffer from congestive collapse, a situation where many TCP flows are sending data at a high rate, but very little useful information is being delivered [Jac88]. Therefore, these algorithms are vital for commercial satellite systems that are a part of the global Internet, as well as for NASA missions which want to fly a node on the shared Internet.

The next recommendation made by [AGS99] is use of the IETF's window scaling mechanism [JBB92]. Originally TCP was specified to utilize windows of up to 64 KBytes. However, given the long delays and high bandwidth channels provided by today's satellite systems, 64 KBytes is not adequate for good utilization. The window scaling TCP option allows for windows approaching 4 GBytes.

The final recommendation made in the RFC is use of the IETF's selective acknowledgment (SACK) option [MMFR96]. SACKs allow a TCP receiver to inform the TCP sender exactly which packets have arrived and which have been lost. This allows TCP senders to retransmit exactly those packets that have been lost. SACKs also lend themselves to more advanced congestion control algorithms, enabling TCP to better utilize the available bandwidth.

These recommendations have been shown to improve TCP performance over ACTS [AHKO97,All97,Hay97] as well as several commercial satellite systems. The IETF continues to evolve TCP with enhancements that improve performance over satellite channels even more (for example, by using a larger initial window [AFP98]).

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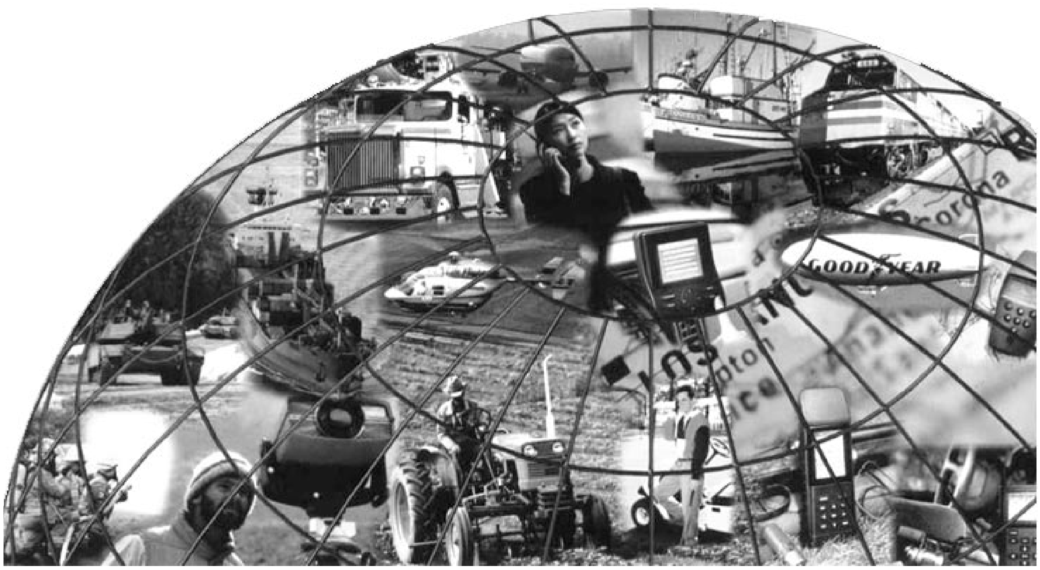
(Global Navigation Satellite System continued.)



Satellite System, or GNSS. The benefits of Satellite Navigation are enormous. For example, the aviation community has anticipated it to be as significant as the introduction to the jet engine.

In mid March 1999 the U.S. Coast Guard announced that Maritime Differential GPS (DGPS) Service had been made operational. The Service broadcasts correction signals on marine radiobeacon frequencies to improve the accuracy of and integrity to GPS-derived positions. Suitably, equipped receivers provide typically 10 meter accuracy, especially benefiting harbor entrance and approach navigation. The system currently provides service for coastal coverage of the continental U.S., the Great Lakes, Puerto Rico, portions of Alaska and Hawaii, and portions of the Mississippi River Basin. Many foreign nations are implementing standard DGPS services modeled after the U.S. Coast Guard’s system to significantly enhance maritime safety in their critical waterways.

The benefits of Satellite Navigation in other areas are also significant, enhancing the way we live and do business. This article provides a sampling of some of the applications and benefits that have been made possible by the contributions of Satellite Navigation technology. As GPS becomes more universal, new and more innovative applications and uses are in the making and will proliferate rapidly with time and imagination. The frequency spectrum bandwidth, currently allocated by the International Telecommunications Union (ITU) for GNSS type applications, is 1559-1610 megahertz. Additional frequencies have recently been proposed for GPS. The unique ITU Aeronautical Radio Navigation Satellite Service allocation provides the protection against interference from other sources required by civil aviation, maritime shipping, and other critical safety-of-life applications. The future growth and evolution of new and improved GNSS safety-of-life applications rely on the preservation of this spectrum. Sharing of this spectrum for purposes other than radio-navigation threatens current and future uses of Satellite Navigation.

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(Global Navigation Satellite System continued.)

A near term example of one of the critical safety-of-life programs that relies on the continued preservation of the full spectrum is the U.S. Federal Aviation Administration's initiative to use ground-based GNSS transmissions to augment space-based GNSS signals. The ground-based signal systems, referred to as pseudolites, are also being used to support more efficient and environmentally sensitive mining operations. The opportunity for multi-purpose pseudolites is just beginning to enter into the manufacturing picture—growth and benefits potential that will clearly be lost without spectrum preservation.

Satellite Navigation is a global public utility which will enable nations to rapidly advance their industries and supporting infrastructures without having to depend on less efficient, outdated, and high cost ground-based position and timing technologies. Therefore, it is most important that the current allocation made by the ITU for the exclusive use of spectrum 1559-1610 remain unchanged.

Satellite Navigation clearly brings increased savings in time and money to its worldwide users. In addition, it enhances the safety and life of the international public that it serves – and this is the true measure by which its worth should be judged.

The GNSS applications that will be covered in the next issue of the SCTL are Space and Public Safety. Following is a very brief overview of those subjects.

SPACE

GNSS is revolutionizing and revitalizing the way nations operate in Space—from guidance systems for the International Space Station's return vehicle, to the management, tracking, and control of communication satellite constellations. Using space-borne GNSS and specialized algorithms, a satellite will soon be capable of navigating itself… making ground stations simpler and requiring fewer operators.

PUBLIC SAFETY

Space based navigation is rapidly becoming an integral part of modern emergency response systems—whether helping stranded motorists find assistance, or guiding speeding ambulance and fire rescue vehicles to a crash site. In the near future, boats and automobiles equipped with autonomous crash sensors and GNSS systems will be able to "Call for Help" even when its occupants are unable to do so.

Other applications, will be presented in future publications are: Agriculture, Aviation, Marine, Environmental, Rail, Surface, Recreation, Surveying, and Timing.

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GPS Set To Become a Global Utility

NASA is Now Leading The Charge To Keep The GPS Spectrum Free Of Interference From Other Users By Assisting in the Creation of Advocacy Groups and Technical Committees to Lobby Against Inmarsat's Proposal.

This article first appeared in the June 18, 1999 issue of The USA National Pavilion Daily Briefing (Paris Air Show 1999), American Aerospace & Defense Industries, Inc. (AADI).

The USA National Pavilion hosted a heavyweight panel of Global Positioning Systems on June 17, 1999 at the Paris Air Show where experts presented the topic of "GPS—An International Utility for the 21st Century". The briefing addressed a number of issues related to the growth and future of GPS including new technology and satellites set to be launched, the Global Navigation Satellite System (GNSS), the airline perspective, search and rescue applications, and radio spectrum issues.

Boeing's Byron Bailey was the first to present discussing the new GPS satellite programs on the boards from both Lockheed Martin and Boeing, including those that were designated Block IIF. The program from Boeing looks to put up a total of 33 satellites starting in 2004 and running over a period of ten years. Originally designed to launch off the Delta II platform Boeing is now gearing these satellites up for EELV.

The goal is to increase the accuracy, availability and integrity of GPS, particularly for civil applications. Bailey did note one hurdle to the program as the life span of the existing satellites in use. Presently these birds are living longer than expected, making it difficult to justify early replacement due to costs.

Captain Edwin Thomas, of United Airlines, followed with his presentation on the perspective of a major airline to the proposals to upgrade the existing Global Positioning System. Thomas zeroed in on the economics, putting his comments forth in the context of a very competitive, deregulated airline industry. After highlighting the benefits to be gained by making investment to upgrade equipment, including improved accuracy and additional features, such as terrain database comparison, GPS clock capability, and GPS-based broadcast and altitude functions reducing need for present equipment, he focused on the down side, including cost and schedule issues; in particular the fair allocation of GPS costs to all users and the ability to receive a return on GPS investments.

In closing, Thomas advised that the US aviation industry was committed to an international, GPS-based future navigation system provided the challenges related to cost, schedule and frequency protection were adequately met.

On the applications side the USDOC/NOAA's James Bailey described Copas-Sarsat, an international humanitarian search and rescue system that uses satellites to detect and locate emergency beacons carried by ships, aircraft or individuals. Since 1982 when the system went into service over 10,000 person worldwide have been rescued through its use.

At this point things became livelier. Two presenters took up the cause of protection to the civil GPS spectrum. First up was James Hollansworth of NASA Glenn Research Center presenting on GNSS. Hollansworth provided the background to Inmarsat proposal to the World Radio Conference in 1997 to add Mobile Satellite service to the primarily civil GPS band at 1559-1610 MHZ. The US successfully led the effort to delay this action until WRC-00 takes place. NASA is now leading the charge to keep the GPS spectrum free of interference from other users by assisting in the creation of advocacy groups and technical committees to lobby against Inmarsat's proposal.

Hammering away even harder on this issue was the FAA Program Director for Spectrum Policy and Management, Gerald Markey, who describes himself as the watchdog and guardian of the US aviation industry's radio spectrum. Markey started with the fact that the international civil aviation requirement for navigation systems is 99.99999% (seven-9's of integrity). The only way to remove the risk of possible interference and ensure the integrity of civil aviation communication, he continued, is to keep the frequency the exclusive domain of its present user—no sharing.

It will be an interesting conference next year when the spectrum issue comes up again.

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Experimenting Spacecraft Control via the Internet

NASA Glenn Research Center (GRC) conducted a joint experiment with GSFC to demonstrate spacecraft control via the Internet. The experiment involved issuing commands to a set of remote devices at GSFC through the Internet and TDRSS from a computer located at GRC. The remote devices, several video cameras, Global Positioning Satellite unit, and a weather-gathering instrument were mounted inside of a truck and driven around GSFC collecting and gathering data information. Furthermore, a remote co-investigator located at another site participated in activating the instruments during this experiment. The experiment proved successful as it demonstrated first time end-to end control of devices through the Internet and TDRSS.

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Recent Meetings of ITU-R Working Parties 7B and 7C

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The Spectrum Management Office, SMO at the NASA Glenn Research Center represents NASA's interests in many international fora. Probably the most important of these are the meetings of the International Telecommunications Union (ITU). The ITU, headquartered in Geneva, Switzerland, is part of the United Nations organization within which global telecommunications are coordinated. Of the various bureaus and sectors that compose the ITU, the Radiocommunications Sector is responsible for frequency regulation. Within the Radiocommunications Sector there are numerous study groups, including Study Group 7 which is responsible for scientific use of the spectrum. Study Group 7 is further divided into four working parties, 7A through 7D. Of specific interest to NASA are Working Parties 7B (WP7B) and 7C (WP7C). WP7B is focused on issues of space research and operations including shuttle and International Space Station (ISS) communications while WP7C focuses on Earth exploration and meteorological systems.

The most recent meetings of WP7B and WP7C were held March 3-10, 1999 in Geneva, Switzerland. Brad Kaufman and John Zuzek from the SMO, were part of the US delegation to the WP7B and WP7C meetings, respectively.

At the WP7B meeting, there were delegations from twenty countries and international organizations. A number of issues were dealt with by WP7B, including: system parameters for determining earth stations coordination areas; sharing in the band 37-40 GHz between space research service systems and fixed satellite service systems; development of a Preliminary Draft New Recommendation on sharing the band 25.25-27.5GHz between inter-satellite service links and proximity links.

The most contentious and controversial issue at the WP7B meeting was the sharing between non-geostationary orbit systems and other systems in the band 13.75-14 GHz. Three footnotes in the International Radio Regulations, S5.502, S5.503 and S5.503A, govern operations in this band. The delegation from France wanted support from WP7B on a change to Footnote S5.502 in the International Radio Regulations. France would like the minimum equivalent isotropically radiated power (EIRP) specified in the footnote reduced. With the current antenna size restriction listed in the footnote, a lower minimum EIRP could provide some interference relief to NASA's Tracking and Data Relay Satellite System. Unfortunately, this lower EIRP could cause potential problems for US radiolocation systems and it was felt that by allowing this change, the next item to be changed would be a reduction in the permissible antenna size. After productive negotiations, we successfully prevented any language in WP7B documents that could be construed as an endorsement of changes to any of the existing footnotes, S5.502, S5.503 and S5.503A without further study by all involved services.

The WP7C meeting had participants from seventeen countries and various organizations and the work was divided among 4 drafting groups: active microwave sensors; passive microwave sensors; Earth Exploration Satellite data transmissions, data collection, and frequency sharing between the Meteorological Satellite Service and the Mobile Satellite Service; and meteorological aids (including frequency sharing with the Mobile Satellite Service). Each drafting group dealt with a number of issues.

A major issue of the WP7C meeting was in the area of passive sensor allocations above 71 GHz. The majority of the meeting time and the participants' efforts were expended on this topic. This issue required the development of a table and supporting text for input into the Conference Preparatory Meeting (CPM). Developing the table and text was difficult because it was necessary to allow for a reasonable allocation of frequencies for all the services interested in using the frequency bands above 71 GHz while protecting bands that are critical to climatological and environmental sensing. The importance of this table and text is that delegates to the World Radiocommunications Conference (WRC) will use the final version that emerges from the CPM as a technical input to aid in the decisions-making process at the Conference. The WRC is the forum where the International Radio Regulations are written and modified and the actual spectrum allocations are made.

In this article, the most recent meetings of the ITU-R WP7B and WP7C were presented. During these meetings, many complex issues are considered. These issues require a lot of careful negotiations and necessitate the delegates to have an understanding of both the technical and political situation.

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Uses of Spaceborne Active Sensors and Their Radio Spectrum Frequency Needs

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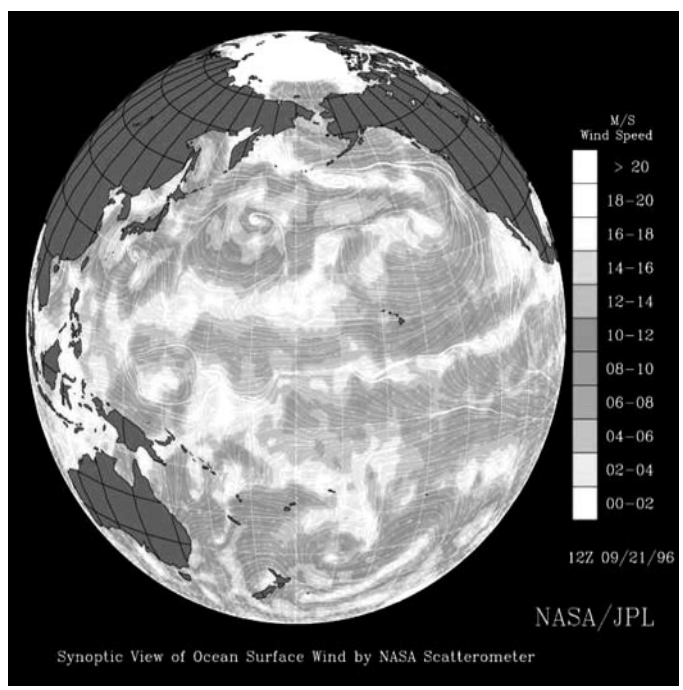
SAR image of Bora Bora, French Polynesia

What is an “active sensor”? An active sensor is a spaceborne instrument used for measuring signals transmitted by the sensor that were reflected, refracted or scattered by the Earth’s surface or its atmosphere. These sensors have a variety of applications related to meteorology and observation of the Earth’s surface and atmosphere. Active sensor frequency allocations are generally shared with other radar and radiolocation systems as such systems are normally compatible with the operation of the sensors. The 1997 World Radio Conference (WRC-97) was very successful for gaining many of these important active sensor frequency allocations.

Synthetic Aperture Radars (SARs) are active sensors that look to one side of the nadir track of the spacecraft, collecting a phase and time history of the coherent radar echo, to provide radar images of the Earth’s surface. The choice of Radio Frequency (RF) center frequency depends on the Earth’s surface interaction with the electromagnetic (EM) field. The RF bandwidth affects the resolution of the image pixels. Typical frequencies used by SARs are 1215-1300 MHz, 3100-3300 MHz, 5250-5460 MHz and 9500-9800 MHz. NASA has flown several different SAR missions on the space shuttle, the most recent being the SIR-C mission on STS-68 in October of 1994.

Spaceborne altimeters are active sensors that look at nadir, measuring the precise time between a transmit event and receive event, to extract the precise altitude of the Earth’s ocean surface. The choice of RF center frequency depends on the ocean surface interaction with the EM field. Dual frequency operation facilitates ionospheric delay compensation. For instance, the joint NASA/CNES TOPEX/POSEIDON mission uses frequencies around 5.3 GHz and 13.6 GHz. The signal bandwidth directly affects the height measurement accuracy. Future spaceborne altimeters will also utilize the 17.2-17.3 GHz and 35.5-36 GHz bands.

Scatterometers are active sensors that look at various aspects to the sides of the spacecraft’s nadir track, using



Ocean surface wind speeds and directions over the Pacific Ocean on September 21, 1996 measured by the NASA Scatterometer (NSCAT).

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(Spaceborne Active Sensors continued.)

the measurement of the return echo power variation with respect to aspect angle to determine the wind direction and speed on the Earth's ocean surface. The choice of RF center frequency depends on the ocean surface interaction with the EM field and its variation over aspect angle. The narrow RF signal bandwidth provides the needed measurement cell resolution. For the NASA Scatterometer mission, NSCAT, only 2-15 kHz is needed for the required 25 km resolution. Scatterometers use 5250-5350 MHz and 13.25-13.75 MHz and other instruments are planned near 8.5 and 9.6 GHz as well as 17.2-17.3 GHz and 35.5-35.6 GHz. Among its many uses, the NSCAT instrument has been used to collect data to study the El Niño meteorological phenomenon.

Precipitation radars scan perpendicular to the nadir track, measuring the radar echo from rainfall to determine the rainfall rate over the Earth's surface, mainly in tropical regions. The choice of RF center frequency depends on the precipitation interaction with the EM field. The backscatter cross section of a spherical raindrop is related to the refractive index of the drop's water content. The narrow RF signal bandwidth provides the needed measurement cell resolution. The joint NASA/NASDA (National Space Development Agency) Tropical Rainfall Measurement Mission, TRMM, uses only a 0.6 MHz bandwidth. Precipitation radars currently use the 13.25-13.75 GHz frequency band, although instruments are planned for the 17.2-17.3 GHz and 24.05-24.25 GHz bands as well.

Cloud profile radars look in the nadir direction, measuring the radar echo return from clouds, to provide a three dimensional profile of cloud reflectivity over the Earth's surface. The cloud profile radar antennas have very low sidelobes so as to isolate the cloud return from the higher surface return illuminated by the sidelobes. The narrow RF signal bandwidth provides the needed measurement cell resolution. Current cloud radars utilize the 78-79 GHz and 94-94.1 GHz bands.

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Intelsat

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In October of 1998, the Advanced Communications Technology Satellite (ACTS) Project Office was contacted by Intelsat Corporation with a inquiry as to whether ACTS could provide a demonstration of Ka-band technology capabilities for their Corporate, Spring 99 quarterly planning meeting. The focus of the demonstration was described to NASA as a showcase of the advantages and advancements in Ka-band systems to help promote Ka-band for a next generation Intelsat system being proposed by the Intelsat Advanced Sytems Group. Also, this demonstration had as one of its goals, a comparison of current Ka-band system capabilities with similar Ku-band system capabilities to the members of this Intelsat Corporate decision making body.

Following several discussions between NASA and Intelsat representatives, a proposal was submitted to the ACTS Project Office identifying the use of ACTS, and a compliment of three small ground stations, one configured as a Hub terminal and two remote terminals. The proposal identified the use of several applications those being:

(1) Primary Rate ISDN (Integrated Services Digital Net work) service at the Hub terminal and two Basic Rate connections at to the Remote terminals to communicate with each other via the Hub ISDN switch and the outside world
(2) a high data rate Internet/Network connection at the Hub terminal providing service to, and between, both remote terminals
(3) a configuration of fractional T1 Video tele-conferencing equipment for point-to-point operation between the remote terminals
(4) high data rate MPEG-2 format video transmission between the hub terminal and each remote site.

Once the proposal was received at NASA, a team of engineers set to work on a system that could accommodate these requirements. With the higher data rates described in the proposal and the application capabilities requested, the task was turned over to Rich Reinhart who leads the ACTS Ultra Small Aperature Terminal (USAT) development for the ACTS Project Office. The USAT terminals had in the past been used for each of these applications independently, but had never been used to combine this aggressive compliment into a single system, which presented the challenge.

With the help of Greg Kubat (Analex Corp.) and Terry Bell (Comsat) to assist with details of the specific applications, Dave Kifer (Cortez) to lead the USAT terminal installation and testing, Rich Reinhart presented a conceptual system to accommodate all of Intelsat's requests. The system configuration proposed the use of the 50MHZ total bandwidth available to USAT and an FDMA (Frequency Division Multiple Access) allocation within that bandwidth to provide all features of the proposed Intelsat system. Nine separate frequencies were needed for the array of applications. Initial testing of the system was completed in Cleveland with this entire nine channel frequency utilization. By November 1999 the final system configuration was in the process of being built and tested (figure below) and by December 99 final tests were being completed.

The system was comprised of three USAT outdoor units. The first site, the Hub site, used a 1.2 meter antenna with a 2 watt amplifier, and the remote sites used .6 meter dishes and 1 watt IPA at each. All three utilized tracking to accommodate the inclined orbit operation of ACTS.

The compliment of support hardware for the system began with a set of Comstream 701 satellite modems with high speed option and fractional T1 option cards. These provided the IF frequency transmit/receive for each USAT and the standard interface with downstream applications hardware for timing and communication interfaces. For the Internet/Networking and video-teleconferencing applications, Comstream modems communicated over T1 interfaces to a set of CSU/DSU devices to allow DS0 selectable data rates for each. For the ISDN application, each of the remote sites were provided a 3 channel, 192kb link to accommodate the 2B+D basic rate. The Internet application used 5 channels (320kb), and for video-conferencing 1/2 T1 or 12 channels providing a 768kb link was used. The MPEG-2 video application was provided as transmit-only at the Hub and receive-only at one of the remote site terminals. This interface also used a Comstream modem interfaced over RS-449 to accommodate the 6.144 Mbps fixed data rate of the encoder/decoder pair.

After completing testing of this system at GRC in February of 1999 a GRC demonstration was performed for Mohamed Ould-Yahya, the Intelsat Project Representative. During that visit, full system capabilities were demonstrated, the system was accepted, and final plans were made to present the demonstration to three separate Intelsat groups during the February/March 1999 timeframe.

The system was presented to the Intelsat Planning and Technical committees during February and performed very well, with very positive feedback from those who attended. Most were very surprised to see the quality of the service the system provided using only the small 1.2 and 0.6 meter antennas. NASA is currently awaiting the final report from Intelsat as follow-up to this activity. However, Mohamed Ould-Yahya of Intelsat was very pleased with the outcome of the demonstration and expressed sincere appreciation to the NASA team and Project Office for helping him to meet the goals of this activity.

This demonstration was done under a fully cost reimbursable Space Act Agreement with Intelsat.

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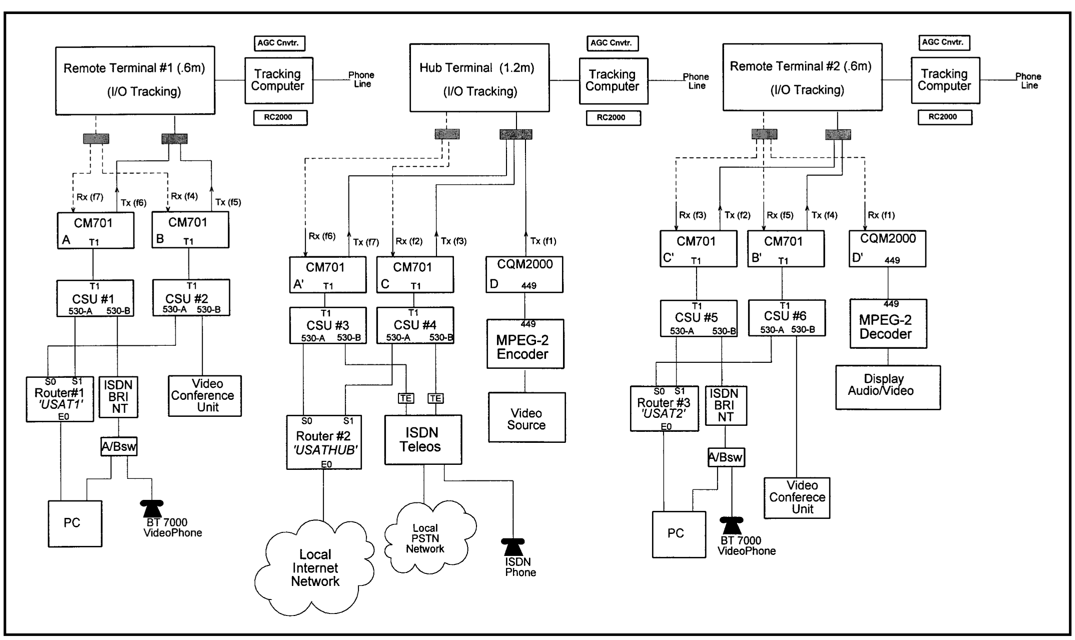

ACTS FDMA network demo.

Shaping The Future Minds

Dr. Kul Bhasin, Chief of the Satellite Networks and Architectures Branch, educates second graders at Goldwood Primary School located in Rocky River, Ohio, about the importance of satellites and the impact they have upon our lives.

Janice L. Zarrelli
ADF Corporation
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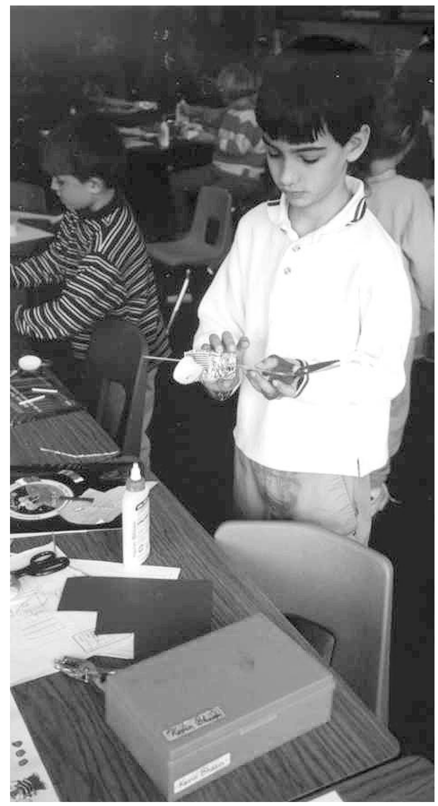
A knowledgeable adult can have a lasting impression upon a child, whose dreams about the future is higher than the stars.

Dr. Kul Bhasin, Chief of the Satellite Networks and Architectures Branch, sparks interest among students when he visits local elementary schools and shares his knowledge about satellite technologies and how satellites communicate through space. He has developed appropriate age-level lesson plans, with the assistance of several teachers, where he has incorporated discussions, video presentations, writing exercises, and "hands-on" projects in the classroom.

By letting children participate in "hands-on"projects, Bhasin believes that children pay close attention to details and are more apt to learn. One exercise that the children are asked to do is design a satellite made from aluminum pie tins and soda drinking straws. Not only must the students use their own imagination in creating a satellite model, but they must also develop potential applications and benefits of their spacecraft.



Second grader from Goldwood Primary school is deep in thought as he designs his own satellite model out of aluminum pie tins and soda drinking straws.

Bhasin believes teaching these students at a young age about satellite technology will encourage students to enjoy learning Math and Science. Who knows if one of these children will grow up to be an engineer, scientist, researcher, or perhaps an astronaut?

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Telecommunication Series Signals Interest in Youth

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Students today represent one of the largest consumers of telecommunications technology. They spend hours each week surfing the Internet and emailing friends around the world. Pagers and cell phones are common accessories of many high school students. They live in world where direct TV is rapidly becoming the norm, and they can't remember a time when telephones were rotary-dial. Today's students are products of the "Information Age."

Yet, as familiar as teenagers are with telecommunications technology, they rarely give thought to how these tools actually work. In order to excel in a world driven by the need to communicate quickly, reliably and globally, it is more important than ever for students to understand the fundamentals of telecommunications. Recognizing this need, the Space Communications Program at NASA Glenn Research Center joined forces with Cleveland's local PBS station, WVIZ, to provide area high school students the opportunity to learn the basics of telecommunications in a high-tech, interactive, informative setting.

This community partnership provided access to a WVIZ interactive studio classroom setting, and the opportunity for the Space Communications Program to develop a six segment series on telecommunications. The WVIZ studio allows a presenter to instruct a live, in-studio audience as well as up to three additional classes in the greater Cleveland area that are connected to the studio via fiber. The instructor communicates with the three classrooms using three different TV monitors, and each of the distant classrooms can see and hear the instructor, as well as, the other two participating classrooms. In addition, WVIZ broadcasts such educational lectures to local schools which only have the capability to receive the broadcast.

The six segment series, developed by the Space Communications Program, covered a broad range of telecommunications topics including: the history of telecommunications, the fundamental physics of telecommunications, analog and digital communications, multiplexing, networking and the Internet, and satellite communications. To effectively illustrate the impact of telecommunications technology, the SCP incorporated the use of the Advanced Communications Technology Satellite (ACTS) satellite for two segments, providing students with learning opportunities that only years ago would have been impossible.

In the first session, Dr. Hans Kruse, a telecommunications professor from the Ohio University in Athens, Ohio, addressed students on the topic of Networks and the Internet from his classroom at Ohio University. This example of distance learning allowed the students access to an expert on the field of networking without geographic distance serving as a barrier.

The second segment allowed students to take a "virtual field trip" to the ACTS Master Control Facility at NASA Glenn Research Center. Without leaving their classrooms, students were able to tour the satellite ground station which controls the ACTS satellite. The "live" video of this tour was transmitted from the ACTS satellite to the WVIZ broadcast station.

The six segment series was aired in April, 1999 and was immediately deemed successful. Initial feedback from both students and educators has been very positive. Plans are underway to offer this course again to students in the upcoming school year.

In addition to impacting students through this partnership, the SCP is in the process of incorporating the content of this series into a tutorial website, thereby vastly increasing the audience to whom this valuable information is made available. With the wide array of telecommunications technology available today, it only makes sense to utilize these technologies to educate both students and the general public in order to help them better understand the products which have become an integrated part of their daily lives.

For more information please e-mail us at:
Spacecom@grc.nasa.gov
and refer to Article: 2299-09

Outstanding Commitment to Project Management

Janice L. Zarrelli
ADF Corporation
Space Communications Office

Larry Wald and Project Development Integration Branch Chief, Denise Ponchak.

In addition to outstanding commitment to the field of project management at NASA Glenn Research Center, Larry Wald, Space Internet Direct Data Distribution (D3) Project Manager, received the "Cleveland Federal Executive Board Employee Recognition Award" for his inspirational job performance and participation in community service.

Being a project manager since 1988, Wald has lead several projects within the Glenn Microgravity Science Division, for both the Space Shuttle and International Space Station, and has worked with Glenn and other NASA personnel to define and strengthen the science of project management through his involvement with the NASA Project Management Development Program. His most recent accomplishment includes being certified as a Project Management Professional by the internationally recognized Project Management Institute.

Not Only has Wald focused his efforts on job performance, but he is an active participant in community involvement. As a member of the Lewis Speakers Bureau, he has spoken to secondary school students throughout Northeast Ohio on the various career opportunities at NASA. In addition, he has acted as President, Treasurer, and coach for the Oberlin Youth Soccer Association.

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SCP Employees…*On The Move*

Janice L. Zarrelli
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Thomas vonDeak has recently joined the Spectrum Management Office. His responsibilities include interfacing with Space Operations Management Office (SOMO) in their commercialization efforts involving the use of spectrum related resources, reviewing spectrum authorization processes implemented in NASA and CSOC procedures, and surveying future spectrum requirements of NASA projects. Previously, vonDeak was a member of the Satellite Networks and Architecture Branch, within the Communications Technology Division.

Israel Greenfeld was recently named to the position of Communications Systems Analyst of the Space Communications Office where his duties include conducting systems level studies for satellite based communications systems with an emphasis on emerging commercial assets. In addition, he is responsible for performing economic studies on communications systems while maintaining contact with NASA and Industry regarding future trends. Prior to this position, Greenfeld worked in the Engineering Design and Analysis Division (EDAD) at NASA Glenn Research Center.

Warm Welcome to New Employees

Lawrence Foore of Analex Corporation was recently named to the position of Communications Systems Engineer. His responsibilities include performing modeling and simulation of satellite and terrestrial data communication networks for development of the Advanced Communications for Air Traffic Management (AC/ATM) element of the NASA Advanced Air Transportation Technologies (AATT) Project.

Matthew Mohr, of the ADF Outreach staff, was named to the position of Graphic Designer. His responsibilities include providing graphical designs and concepts for the Space Communications Program Web site, as well as various projects within the Space Communications Program.

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"e-Merging" Developer Attains Certification

Janice L. Zarrelli
ADF Corporation
Space Communications Office

By passing the Implementing and Supporting Microsoft Internet Information Server 4.0 Exam, **Thomas Kudla**, Programmer/Database and World Wide Web Analyst, has become a Microsoft Certified Professional (MCP). The exam measures the ability to implement, administer, and trouble-shoot information systems that incorporate Microsoft Internet Information Server version 4.0. With the completion of this first test, Kudla's future plans include the attainment of other Microsoft certifications.

Thomas Kudla

The second certification, which he is currently preparing for, is Microsoft Certified Professional+Internet (MCP+I). This level requires the completion of two additional tests which are used to gauge the ability to specialize in Internet Technologies.

Kudla's ultimate goal is to complete seven additional tests. Upon completion of these tests, he would be qualified to receive the Microsoft Certified System Engineer + Internet certification for Internet Technology Professions. In order to obtain this certification the individual must have the ability to enhance, deploy, and manage sophisticated Intranet and Internet Solutions including a browser, proxy server, host servers, database, and messaging and commerce components, as well as manage and analyze Web sites.

For more information please e-mail us at:
Spacecom@grc.nasa.gov
and refer to Article: 2299-12

Take Our Daughters to Work Day—April 23, 1999

Barbara L. Wamsley
ADF Corporation
Space Communications Office

The National Program, "Take Our Daughters to Work," was celebrated here at NASA Glenn Research Center on Friday, April 23, 1999. The program is an initiative sponsored by the MS Foundation for Women which has dedicated this program as a public campaign for keeping our daughters strong and resilient, encouraging them to break down gender and racial barriers so they too can prepare to take advantage of all educational and employment opportunities. The John H. Glenn Research Center (GRC) extended the program to include all children ages 9 to 15 years of age.

The Women's Advisory Group, with the support of the Equal Opportunity Committee and the NASA Glenn Business and Professional Women sponsored the day. The children were encouraged to see how their parents spend a day at the "office", touring several sites at GRC, and having hands-on activities.

The Space Communications Visitor Center was identified as one of the tour sites. A guided tour of the Advanced Communications Technology Satellite Ground Station, built in 1990, was given. Children and parents had the opportunity to view the 24 hour operations of the state-of-the-art Ka-band satellite, designed and developed by GRC. The facility provides a historical perspective of NASA's advances to the field of Space Communications while showcasing relevant new technology areas under investigation. Video presentations about the benefits of Space Communications Technologies was presented. At the end of the tour the children had an opportunity to experience their voices 22,000 miles in space.

The Space Communications Visitor Center is open daily for tours organized through the NASA Glenn Research Center Visitor Center.

For more information please e-mail us at:
Spacecom@grc.nasa.gov
and refer to Article: 2299-13

Astronaut Day

With thanks from the Astronaut Class of 1998

The 1998 Astronaut Class visited NASA Glenn Research Center on April 20, 1999 as part of their training curriculum. This year's class membership was made up of 25 students; eight of them training to be pilots, and the remaining 17 as mission specialists. Among the twenty-five students there were seven from the US Navy, two from the US Air Force, two from the US Army, and one from the US Marines.

The class toured the Space Communications Visitor Center facility where ACTS Project Manager, Bob Bauer presented new technologies and developments within the Space Communications Program. In addition, the Advanced Communications Technology Satellite Experiment (ACTS) was recognized and acknowledged for its accomplishments and developments in the satellite industry.

Before leaving NASA GRC, the students showed their appreciation by presenting Bob Bauer with an autographed class photo.

For more information please e-mail us at:
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and refer to Article: 2299-14

Technical Listings

Rainee N. Simons, Richard Q. Lee, “Design of Broadband Vertical Transitions for Tapered Slot Antennas”, IEEE AP-S International Symposium, 1999.

Afroz Zaman, Rainee N. Simons, Richard Q. Lee, “Proximity-Coupled Dual Polarized Patch Antenna”, IEEE AP-S International Symposium, 1999.

Rainee N. Simons, “A Millimeter-Wave Cavity-Backed Suspended Substrate Stripline Antenna”, IEEE AP-S International Symposium, 1999.

K. Goverdhanam, Rainee N. Simons, L.P.B. Katehi, “Novel Three-Dimensional Vertical Interconnect Technology for Microwave and RF Applications”, IEEE MTT-S Internation Symposium, 1999, Anaheim, California.

F.A. Miranda, F.W. Van Keuls, G. Subramanyam, “Correlation Between Material Properties of Ferroelectric Thin Films and Design Parameters for Microwave Device Applications Modelling Examples and Experimental Verification”, International Symposium on Integrated Ferroelectrics, Colorado Spring’s, Colorado, March, 1999.

For more information please e-mail us at:
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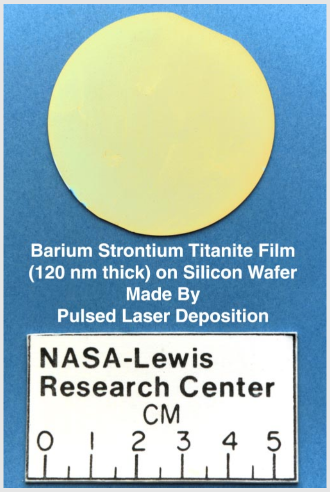
Growth of Ferroelectric Films for Solid State Microwave Devices

In the December, 1998 issue of the SCTL, the article titled “Ferroelectric Technology” by Robert Romanofsky, Richard Kunath and Felix Miranda, introduced the discovery of ferroelectric films ($Ba_xSr_{1-x}TiO_3$). This article features that development.

Ferroelectric films ($Ba_xSr_{1-x}TiO_3$) in support of the frequency and phase agile microwave research have been successfully grown at NASA Glenn Research Center. The films are grown by pulsed laser deposition and can be grown on a variety of substrates up to 55 mm diameter with less than ±2% thickness variation over the wafer. X-ray diffraction data suggest that the films are comparable to the best reported films from other laboratories. The growth of this film on silicon is used to illustrate that pulsed laser deposition has the capability of growing uniform films. The growth is approximately 1.2 Angstroms per second.



Barium Strontium Titanite film on a two inch silicon wafer.

The Barium Strontium Titanite film has the same composition as ferroelectric films recently grown on Lanthanum Aluminate. Those films have shown the highest tunability versus microwave losses of any ferroelectric films that we have measured from outside sources.

This preliminary work is continuing with the goal of finding a composition of ferroelectric film and deposition properties on substrates suitable for microwave applications that has a tunability versus microwave losses (dB) of greater than 120° per dB. If this is achieved high gain phase array antenna are possible.

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